

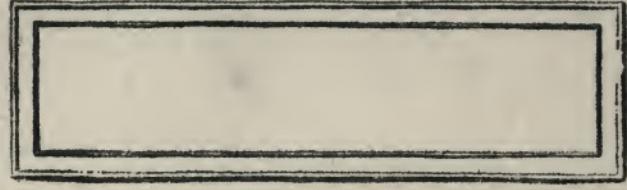
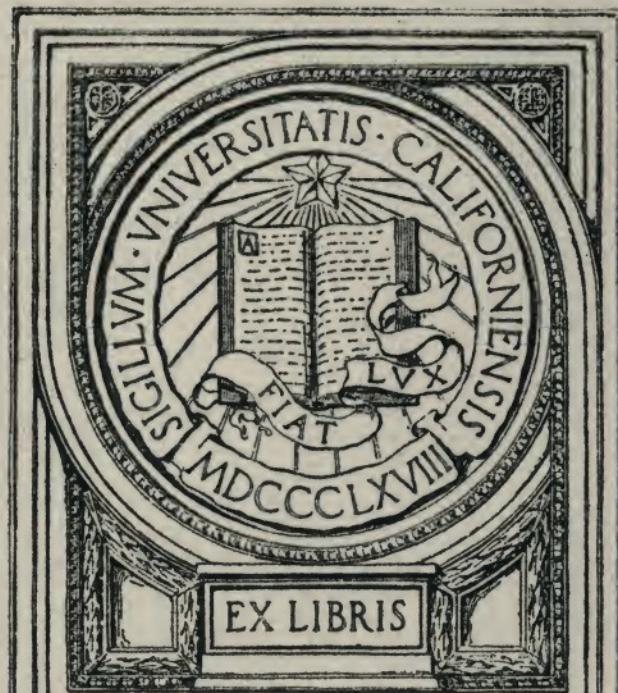
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Industrial Fatigue

IN ITS RELATION TO

Maximum Output

By

HENRY J. SPOONER, C.E.

FOREWORDS

By

Sir ROBERT HADFIELD, F.R.S.,
AND
Mr. J. R. CLYNES, M.P.

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INDUSTRIAL FATIGUE

IN ITS RELATION TO

MAXIMUM OUTPUT

By

HENRY J. SPOONER, C.E.

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FOR BEGINNERS," "ELEMENTS OF GEOMETRICAL DRAWING,"
"INDUSTRIAL DRAWING AND GEOMETRY," "ENGINEERING
WORKSHOP DRAWING," ETC., ETC.



With Forewords by

Sir ROBERT A. HADFIELD, F.R.S., D.Met., D.Sc.
(Chairman of Messrs. Hadfields, Ltd.)

AND

Mr. J. R. CLYNES, M.P.

(District Secretary of the National Union of General Workers
and Member of the Government Reconstruction Committee
and of the Health of Munition Workers' Committee).

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FOREWORD.

By

SIR ROBERT A. HADFIELD.

I HAVE much pleasure in writing a few words with regard to Professor Spooner's able contribution on "Industrial Fatigue in its Relation to Maximum Output." The articles deal with a wide range of problems that are of importance in relation to production, industrial efficiency, and the well-being of the workers.

As to the advantage of restricting the number of working hours and abolishing Sunday work, my own firm, Messrs. Hadfields Limited, Sheffield, have for the past twenty-three years adopted a 48 working hours' week and have found it a decided advantage. Indeed, we could not for a moment think of going back to the old working hours. As an ounce of practice is worth much theory, the above statement, I trust, will carry conviction with it.

Further, I may explain that during the early part of the War, owing to great pressure of work, our industrial establishment, employing some 15,000 hands, never shut down except for a few days ; that is, excepting one or two holidays, we ran clean through for eighteen months without a stop from Monday morning until Sunday night : but it did not pay. For the last few months, and with the permission of the Ministry of Munitions, we have knocked off Sunday work, the result being that our output has been equally as great. I think this is a remarkable proof of the inadvisability of employing non-stop and overtime methods.

B

I notice on page 37 reference is made to the work of Mr. Frederick W. Taylor, the American Investigator and Engineer. I knew the late Mr. Taylor, and a most able man he was. But I am bound to say that I do not believe in all that the American System of "Scientific Management" apparently stands for, as it strikes me that a feature of it is that it tends to make the workman into a machine when after all he is a human being. It is true that Taylor's system of Scientific Management has made considerable headway in the United States, but apparently it has recently received a check, as I read only a few days ago in "*Iron Age*," the leading American Iron and Steel publication :—

"In spite of the extraordinary showing made by the reports to the Ordnance Bureau of the demoralising effect of abolishing scientific shop management in the arsenals, the House Committee has again included in the Army Bill the prohibition of time studies and premium or bonus payments. In view of the action taken by the Senate, which accepted this prohibition as a feature of the Fortifications Bill, it may be assumed that all the National Defence Bills, as finally enacted, will forbid the use of scientific shop management systems."

It is true this paragraph talks about the demoralising effect of abolishing Scientific Shop Management. On the other hand legislative abolition such as mentioned can hardly have taken place, so it seems to me, without the efforts made having practically failed to give general satisfaction. Whilst I believe in the argument of a proper day's work for a proper day's pay, and in the adoption of improved methods that eliminate unnecessary fatigue, I am strongly opposed to any attempts being made in the direction of driving the workers.

I regret great pressure upon my time prevents a longer contribution, but would again state how much I have been interested in considering the very instructive articles contributed by Professor Spooner.

ROBERT A. HADFIELD.

FOREWORD.

By

MR. J. R. CLYNES, M.P.

THESE articles are the work of a trained hand. They are the product of a skilled and sympathetic observer. They are a practical contribution to the solution of problems which may never be solved to everyone's satisfaction, but which must be better handled after the War than before it.

To the conclusions of Professor Spooner, I would state three outstanding impressions which have remained in the minds of workmen. When changes have been proposed to secure increased output, workmen have felt certain that such changes would mean reduced wage rates, and their certainty rested upon experience. They were confident that the more they produced the sooner they would be unemployed, and they found results in some occupations to support this view. They had a natural objection to being made the mere instruments for certain unknown material ends which would give greater gain to others than they themselves derived.

It will be difficult to diminish, not to say dispel, these natural impressions which a few generations of industrial experience have engendered. It will not do to try and reduce the conditions of fatigue in order that workmen should be able to produce more. That will be one of the results, but to set it up as an object would be fatal for the main purpose, and would arouse even greater discontent than conditions of fatigue may now provide.

The workman does not look with favour upon methods designed scientifically to speed him up in order that, without making him either a more skilled workman or a more contented human being, he should be a more effective producer of marketable goods. The human machine works to limitations not applying to other machinery. Other machinery should be regulated by the limits of human capacity : instead of men being driven more and more to a point beyond their normal physical powers.

Experience in the early months of the war of extensive munition production showed that long hours, excessive overtime, and laborious week-end work, were not a contribution to increased output, and had the harmful result of causing excessive illness and in many cases, serious and wasteful breakdown of health. In not a few of the cases of industrial disturbances and stoppages, a contributory cause to men ceasing work has been a state of physical exhaustion and inevitable indifference to whatever might happen.

Increased production is all important, but it should be secured with two other conditions. One is that fair share of the increased rewards should go to the producer : and the other is that the producer himself must be regarded as a man first, and a workman afterwards. Both as human being and wealth producer he would be all the better for treatment in the spirit of the suggestions and proposals of Professor Spooner.

J. R. CLYNES.

PREFACE.

THE articles republished in the following pages were written in November, 1916, in response to an invitation from the Editor of *Co-partnership* to give my views on the subject of "Industrial Fatigue" for publication in his journal. In thinking over the matter it appeared to me that, at this vital juncture, I could profitably attempt a discussion of fatigue problems from the standpoint of production. As a diligent student of psychology and of the science of industrial engineering I have for years lost no opportunity of increasing my knowledge of the working of the human machine, and have endeavoured to profit by the investigations of others. Wherever such investigations have been referred to in these pages I believe I have acknowledged my indebtedness. The researches which have been carried out since 1914 have considerably increased our knowledge of an important and fascinating subject; for we must agree with Pope, that "the proper study of mankind is man." We must not forget that the child is father of the man. So we should begin with the child, and in training him in all the stages to become a contented, happy, capable and useful citizen, see that in becoming efficient he does not suffer from unnecessary fatigue. Every educationist knows how much patience it requires to recall vagrant inattention and to stimulate sluggish indifference. And we shall never attain a high degree of educational and industrial efficiency until we give more study to the psychology of attention. If attention be deep and long-continued it is very fatiguing, and not a little of the absence of order in class work of all kinds is due to that last physical condition exacted by attention which physiologists have called dynamogeny,* that is, "the power which

**Dictionnaire encyclopéd. des Sciences Médicales.*

certain parts of the nervous system possess of suddenly evoking an augmentation of activity, through a purely dynamic influence." Dr. Montessori and Sir Baden Powell understand the psychology of children and young people and the importance of incentive. Hence their phenomenal success in harnessing the activities of children in the cause of education and good citizenship.

Forewords have most kindly been written by Sir Robert A. Hadfield, a great and humane Captain of Industry, and by Mr. J. R. Clynes, a patriotic and statesmanlike representative of Labour. I greatly appreciate these, and they will, I am sure, be read with interest. Although these sympathetic and critical introductions will speak for themselves, I feel that a remark or two touching them may be permitted. It is a happy omen for the future that when improved methods of production are discussed the first to fear that they may tend to overstrain the workers are, not the workers themselves, but some of the most respected representatives of Capital. Thus from the expressed opinions of such ideal employers as Sir Robert Hadfield and Sir William Lever, these pioneers of improved working conditions of Labour might conceivably refrain from the adoption of a system that has great potentialities if it appeared to them to possibly embody methods that are inimical to the well-being of the workers. But in at least one development of improved methods there is often some misapprehension. For instance, by suitable camera work most manipulative operations can be simplified and improved, in such a way as to reduce fatigue at the same time. As a single example, there is presumably one right way of manipulating the ordinary chipping hammer, but many wrong and fatiguing ways, but who has ever heard of anyone trying to find out the least fatiguing way of handling this simple tool? We must pay more attention to animal mechanics, if we are to humanise the exhausting operations of our workers; and those who may doubt the wisdom of employing motion studies to

relieve the worker and increase his output would do well to read a convincing letter from Mr. Frank Gilbreth, the great industrial efficiency engineer, which appeared in *The Engineer* of the 4th May, 1917.

On April 20th, Mr. Michael Longridge delivered his presidential address before the Institution of Mechanical Engineers. The retiring President, in introducing him, referred to him as the greatest master in the country of the pathology of steam machinery. The address was so fine and so convincing, and touched upon so many points that are of living interest to employers and employed in connection with our subject that I cannot refrain from quoting him, particularly as his great authority so strongly fortifies many of the views I have endeavoured to establish. Dealing with Workshop Organisation, he said :—

“ Except in a few cases, workshop organisation here has not received the attention given it in America and Germany. There are still shops without definite planning of the progress of the work, without adequate equipment of jigs and gauges, and without standard shapes of tools or a tool-room : where men drift about in search of tools and tackle, or wait in idleness for drawings or materials ; where machinery is obsolete and light so bad that good work could not be done if the machinery were up-to-date. Such shops must go. They cannot compete in price or quality of work with those in which what is known as “ scientific management,” or anything approaching it, prevails ; where the progress of every job is planned to the last detail before it is sent into the works ; where machinery is so arranged that each piece passes through the whole series of operations to be performed on its pre-determined order and without pause, and is immediately succeeded by another piece to undergo the same cycle of operations ; where labourers and tackle for fixing the work are ready the moment they are wanted ; where drawings, gauges and tools properly ground to standard shapes come with the work ; where cleanliness, light and comfort reign, and where endeavour is made to get the workman to regard his work more as a problem to be solved than a task to be got through.”

Mr. Clynes, as a Parliamentary representative of Labour and as District Secretary of the National Union of General Workers, is exceptionally well qualified to voice the views and feelings of our workers, and his

able, restrained, convincing and human remarks on the attitude of Labour in relation to some of the problems discussed in these pages will surely be read with sympathetic interest. Indeed, they tempt me to again refer to Mr. Longridge's Address, in which he suggests that employers also should consider how far limitation of output and objections to piece-work, two of the most serious causes of difference with the Unions, are due to their own short-sighted policy in cutting Piece-work Rates. He said :—

“The case has been very plainly put by Mr. Barnes, M.P. ‘The system,’ he says, ‘has been a failure because, in the stress of competition, piece-work earnings have tended to slide downwards to what previously had been a time-work wage.’ Indeed, it would almost seem to have been an article of economic religion that a workman’s earnings should be limited by precedent. And thus we go on in a vicious circle, the master unable to increase wages because the workman will not give the necessary output, the workman limiting the output because the master does not raise the pay.”

The attainment and maintenance of peace between master and man is of such paramount importance to the State and the Empire that I cannot apologise for quoting in conclusion Mr. Longridge’s eloquent peroration, which reached a lofty plane of fervid patriotism and was received by a representative and influential meeting with the greatest enthusiasm. He said :—

“ You cannot drive 2,000,000 trade unionists, but you can educate and persuade them. ‘ In a national crisis men should think more of what they could give than what they were likely to get,’ said a great Labour leader to the Manchester Trade Union Congress only three months ago. Can we not act upon his words—the time is ripe ? We stand to-day upon a peak of circumstance uplifted by the war, our eyesight cleared by common peril, our sympathies unsealed by common pain. Behind us are the dark days of the past, before us on the far horizon is the new industrial world. Can we not turn our backs upon the night and march in faith, in hope, in charity, towards the dawn—the dawn of a new day when England shall be Merrie England in the noblest sense, wherein employer and employed shall live in peace and work together for the glory of their native land ? ”

HENRY J. SPOONER.

May 14th, 1917.

CONTENTS.

SUB-HEADINGS.

	Page.
• Output not necessarily proportional to the hours worked ..	13
• Official Investigations Relating to Fatigue ..	15
• Overtime and Sunday Work ..	17
• Psychology and Fatigue ..	18
Wide Range of Factors in Physiological Investigations ..	18
Definition and Causation of Fatigue ..	19
Man-power, or the Labouring Power of a First-class Man ..	21
Relation of Work done and Internal Work of the Human Machine ..	21
Rest from Fatiguing Labour. Weber's and Taylor's Laws ..	22
The most Efficient Length of Working Day ..	23
Experiments on Shortening the Hours of Labour (Balancing) ..	24
Two Shifts versus Three Shifts ..	25
The Five Hours Spell ..	26
Effect of Interest or Incentive on Output ..	26
Unnecessary Fatigue in its Relation to Output ..	27
Trifling Matters may Cause Fatigue ..	29
High Cost of Materials due to Wasteful Methods ..	29
The Science of Shovelling ..	30
The Efficiency Engineer and the Economy of Scrapping ..	30
Dilution and Sub-division of Labour ..	31
Reclassification of Trades ..	32
Typical Scheme of Reclassification ..	32
Management, Traditional and Scientific ..	34
Restriction of Output ..	35
Remedy for Restriction ..	35
Scientific Methods in Management ..	36
A Secret of Germany's Remarkable Industrial Progress ..	37
Marvels of Waste Prevention. Increased Output by Less Work ..	38

	Page.
A Motion Study	39
Hope for Disabled Soldiers	40
The Two Methods of Attacking the Problem of Disablement	40
Use of Time Studies in Increasing Output	42
Iron Plate Punching Timed	42
Speeding Up Machine Tools	43
The Importance of Efficient Welfare Work	44
The Housing Question	45
Welfare Supervision	46
The Duties of Welfare Supervision	46
Desirable Additions to the Above	47
Economic Loss due to the Mobility of Labour ..	50
Labour Turnover	50
Employment Departments	51
Inefficient Labour	52
Hasty Discharges of Workmen	52
The Labour Turnover Problem	53
Scientific (or Methodical) Management	54
Elements of Scientific Management	54
After the War Problems	55
Unlimited Industrial Expansion	56
Urgent Problems Awaiting Solution	57
Conclusions	57



Industrial Fatigue in its Relation to Maximum Output.

By Professor SPOONER, C.E., M.I.Mech.E., F.G.S.

The question as to what number of hours a week an employee should work to enable him to produce the largest output without injurious fatigue, is a pressing one of paramount national importance ; the problem is one that is more easily enunciated than solved, as its solution in any given case depends upon a fairly wide range of factors, in addition to the personal element. Now, if the problem involves difficulties in the case of an individual, it becomes complex in the case of a body of men engaged on the same class of work, and still more complicated in a works where a large range of operations and processes widely differing in character is carried out, as we shall see hereafter.

The question at issue has been growing in importance since the outbreak of war, and it has brought to the front the extremely important subject of industrial fatigue, indeed, the war has caused us to give more attention to fatigue during the past two years than it received from us during the preceding half century.

Output not necessarily proportional to the Hours Worked.

The urgent call for shells and still more shells, indeed, for munitions of all kinds, led to workers being called upon to labour very long hours, and in a large proportion of cases seven days a week, but, after a time it was found that the output was far from being proportional to the number of hours per week worked, particularly when the hours were much above the normal, and that in a fairly large proportion of cases there was an abnormal amount of time lost through

illness and other causes. A state of things that certainly might have been foreseen, having regard to the conditions under which a great deal of the work was done, especially in old-fashioned factories, large numbers of which exist in our manufacturing centres, in the London area in particular, works that have been gradually extended in many cases by the addition of adjacent premises or houses ; and there are also a great many works that have been rapidly improvised or converted to enable them to be utilised for the production of munition work ; the invariable characteristics of such shops are abnormal noise, bad lighting, and inefficient ventilation and heating ; in fact, practically most of the causes of unnecessary fatigue, or fatigue that is not directly due to work done ; and in some cases the conditions under which work is done are even still more injurious to health. A case in point might be cited that is typical of far too many in this country ; the writer on visiting an important old factory in London that was engaged on munitions, was made very sad by seeing a poor anaemic looking fellow working at an emery buff in a cellar-like place, in which the lighting was bad, and in which no provision was made for the withdrawal of the deadly emery and brass dust thrown off from the wheel ; indeed, there was practically no circulation of air. Now, this was not a case of a grasping unfeeling employer conducting his business with an utter disregard for the well-being of his employees, as the manager, an intelligent and able man (earning £1,500 a year) is thought well of by the workers : it is rather a case of ignorance in such matters and want of imagination, and it was only necessary to call his attention to the danger to receive a promise that it would be attended to. It might well be asked what were our Factory Inspectors doing to allow work to be done under such unhygienic and fatiguing conditions ? The answer of course is that they are doing all that is humanly possible, but the ground to be covered is so enormous that if we had ten times their number it is doubtful whether there would be enough

of them to periodically inspect all our workshops and factories that now need attention and advice ; valuable advice that is freely given to employers and workers by these devoted servants of the Home Office. Indeed, the State is well served by their paternal efforts to conserve the health, safety and life of our industrial-workers ; but, strangely enough, the workers themselves do not always follow the good advice given them by the rules of their shops and by the Inspectors in matters relating to fatigue and health, particularly when poisonous vapours or gases and harmful dust are concerned. Nor apparently do they appeal to the Inspector when the Factory Acts have not been complied with by their employers.

Fortunately, during the past decade or two many such unsatisfactory works as we have referred to above have been transplanted to the outskirts of the London area in increasing numbers with the greatest advantage to all concerned ; indeed, some of the worst cases the writer can remember are now, after the works have been removed to country districts, perfect models of what industrial works should be for the welfare of the workers, and from nearly all points of view ; as in their lofty, clean, well-lighted, efficiently heated and ventilated shops an atmosphere exists that is inimical to unnecessary fatigue.

But the elimination of unnecessary fatigue in industrial operations involves many other important matters that must be considered, and we may now give some attention to fatigue from the standpoints of the physiologist and the psychologist.

Official Investigations Relating to Fatigue.

The Committee of the British Association appointed to investigate fatigue from the economic standpoint presented its first interim report in September, 1915, and its second interim report in September, 1916, whilst in the middle of September, 1915, the Minister of Munitions appointed a Committee "to consider and advise in questions of industrial fatigue, hours of labour

and other matters affecting the physical health and physical efficiency of workers in munition factories and workshops." The Committee published its first Memorandum, entitled, "Sunday Labour," in November, 1915, and since then the following Memoranda have been published by the "Health of Munition Workers' Committee" from time to time:—"Welfare Supervision" (Cd. 8151; price 1d.), "Industrial Canteens," "Employment of Women" (Cd. 8185; price 1½d.), "Hours of Work" (Cd. 8186; price 1½d.), "Industrial Fatigue and its Causes" (Cd. 8213; price 1½d.), "Special Industrial Diseases" (Cd. 8214; price 1d.), "Ventilation and Lighting of Munition Factories and Workshops" (Cd. 8215; price 1½d.), and "Sickness and Injury" (Cd. 8216; price 1½d.).

In August, 1915, the first interim report on an "Investigation of Industrial Fatigue by Physiological Methods," by Prof. A. F. Stanley Kent, the distinguished Head of the Department of Physiology, University of Bristol, was published by the Home Office as a blue book, followed in September of this year by the second interim report (Cd. 8335; price 1s. 6d.), a book of some 80 pages of most important matter.

At first sight it might appear that a good deal of overlapping in the investigations dealt with in these different papers would occur, but this has apparently been avoided, as we are told in the British Association report that the investigators have been conversant with one another's work.

It is hardly necessary to explain that these publications represent a very large amount of painstaking research, carried out by men of great distinction, and they should be studied by all interested in the urgent national problem of getting the maximum output from our workers' efforts without injury to their health due to accumulated fatigue.

This being the primary object of the Ministry of Munitions' investigations, it is to be regretted that the terms of reference were not drafted on broader lines, so as to include the consideration of any departures from

ordinary workshop methods, practice and processes that the science of management has proved to be profitable in the direction of output.

Overtime and Sunday Work.

Now a careful perusal of the above mentioned papers makes clear that the conclusions as to overtime and Sunday work reached by the investigators through their more or less quantitative experiments and observations agree with those that managers of industrial works have long known to be more or less true.

In the main, it was not the works managers who were responsible for the large amount of overtime and Sunday labour the munition workers have been called upon to work, as in a general way, the most experienced managers have long known that a good healthy worker is capable of working time and a half over a fairly long period without a sensible decrease of production if all the conditions are favourable, but they know that continuous overtime inevitably leads to a marked falling off in the hourly rate and in the day's production of the average worker. In fact, they know that in a certain proportion of cases a substantial increase in the actual total output can be secured by a reduction in the working hours ; and the inquiries conducted by the Ministry of Munitions, the British Association and the Home Office are to a large extent in agreement with the experience of managers. Indeed, we are told in the Memorandum No. 5 "it is noticeable that amongst those in favour of shorter hours are employers who have given the most careful study to the question of industrial fatigue and scientific management."

Physiological methods have been to a wide extent used by the investigators, and the science of the causation of fatigue has been well advanced by them, but apparently there is a noticeable absence of the enunciation of any definite laws comparable with those of Weber and of Taylor ; but, even so, the investigations carry us a long way in the right direction

Psychology and Fatigue.

2 We are truly told that "in the study of fatigue, account has to be taken of many things that are so inexplicable at present in terms of physiology as to be called psychological." Indeed, it is commonly known that fatigue occurs due to anything that affects the nervous system.* Thus noise, worry, flickering lights, inefficient lighting, or light reflected from bright parts of machinery striking the eyes, faulty heating and ventilation, and an atmosphere of fussiness; in fact, anything disturbing to comfort or arresting attention creates a feeling of fatigue in the worker, but in different degrees with different workers, and in different degrees with the same worker due to varying conditions of health. In fact the broad factor of environment affects every worker, but it affects some workers in a remarkable degree. So these complicated conditions make it extraordinarily difficult for physiologists to formulate laws, as no sound judgment can be formed upon a comparatively few isolated cases such as are dealt with in the reports when in our industries the permutations of the varying factors are practically without limit. This is understood, as the following paragraph from the British Association report tends to show. "On the whole, however, in spite of their experiments in school and laboratory, the work of the psychologists is still for the most part the reverse of illuminating for the problems of industry."

Wide range of Factors in Physiological Investigations.

3 The work of physiologists in studying the endurance and the power of recovery from fatigue of the human animal has led to much more satisfactory results, although in this field investigations are complicated by the fact that industrial workers are of various types, ranging from the strong to the weak, from those

*Professor Stanley Kent tells us that "the seat of fatigue is rather on the nervous than on the muscular side."

who enjoy uniform good health to those who are often ill or indisposed, and from those endowed with abnormal energy to those who are lethargic with very little, and, again, from those who conserve their health by paying proper attention to diet, sleep and rest, to those who are careless and intemperate in all things. It has long been known, and the recent investigations have demonstrated it, that different amounts of fatigue will be produced in members of these different classes due to similar activities. Also that the variations in the fitness of the workers day by day affect the amount of fatigue produced, and the power of recovery, as labour is not, as we have seen, the sole cause of fatigue. Indeed, investigations are further complicated by the very wide range of work done in some factories and industries under varying conditions too numerous to mention; thus we have the extremes of heat and cold in furnace work on the one hand and the manufacture of ice on the other, the extremes of noise and silence in the locomotive boiler shop or the coppersmiths' shop on one hand and the watchmakers' assembling room on the other. The extremes represented by the exposure to all weathers of the agricultural worker, the soldiers and sailors to the comfortable surroundings of a designer or accountant working in a well appointed office.

¶ We thus see that fatigue problems of the industrial world are so complicated in most cases that complete solutions are not to be looked for.

Definition and Causation of Fatigue.

¶ At this stage we can profitably give attention to the definition and causation of fatigue and we cannot do better than quote from the admirable Memorandum No. 7, previously referred to, which deals with the matter physiologically:—

“ Fatigue is the sum of the results of activity which show themselves in a diminished capacity for doing work. In ordinary language fatigue is generally associated with familiar bodily sensations, and these sensations are often taken to be its measure. It is of vital importance for the proper study of industrial fatigue, however, to recognise not only that

bodily sensations are a fallacious guide to the true state of fatigue which may be present, and a wholly inadequate measure of it, but also that fatigue in its true meaning advances progressively, and must be measurable at any stage by a diminished capacity for work, before its signs appear plainly, or at all, in sensation.

"In the animal body the performance of work depends on the activities of parts which are best considered under three groups: first, the complex nervous mechanisms of the brain and spinal chord, which are concerned in the initiation and distribution of impulses to action, second, the nerves, which conduct the impulses to muscles; and third, the muscles themselves, which by contracting finally perform external work.

"Fatigue has been separately studied in all these parts. In its essential features the fatigue of all alike has been found, when it occurs, to depend not upon the simple using up—'exhaustion'—of the substances supplying the chemical energy which is liberated during work, but upon the accumulation within the living elements of the products of the chemical changes involved. Fatigue of the animal machine, that is to say, is not to be compared with the failure of fuel as in a steam-engine, or with the running down of a clock weight, but rather with the clogging of the wheels in some mechanism by dirt."

Now, this last clear statement of a physiological fact should be welcomed, as it fits well with the engineer's conception of how the fatigue due to short interruptions of work, lasting perhaps in each case only a few seconds, or at most a few minutes, cannot be considered as the equivalent of an interval of rest equal to their sum; for on the contrary, instead of counteracting the fatigue due to actual work, they necessarily make a further contribution thereto; this part of fatigue being analogous to the idle running of an engine.

To the engineer, the human machine is a marvel of ingenuity, with extraordinary powers of endurance under certain conditions, equipped with wonderful safety devices, not the least remarkable being the one which comes into action due to fatigue; for Professor Stanley Kent tells us (second interim Report) that "the appearance of fatigue is due to the action of a protective mechanism, similar to the safety valve or electric fuse, but, unlike these, acting when energy becomes deficient."

Man-Power, or the Labouring Power of a First-Class Man.

Happily in recent years the use of machinery has greatly reduced the amount of fatiguing labouring work done by man ; but mechanical appliances have not eliminated it, nor, alas, are they likely to in the years to come ; thus the soldier is sometimes called on to make long marches heavily laden with his rifle, pack, &c., the use of mechanical excavators has not abolished the heavy work of the navvy, nor the use of coal cutting machines the strenuous work of the miner, and so on ; this being so, it will always be a matter of interest as to what represents a good day's labouring work.

Many years ago Dr. Parkes, F.R.S., noted what he believed to be the hardest day's work of twelve hours ; the case was that of a workman in a copper rolling-mill whose ordinary day's work, which he considered extremely hard, was raising a weight of 124 lbs. 16 inches, 6,000 times a day, equivalent to 443 tons lifted a foot, or, using the language of mechanics, 443 foot-tons. But occasionally this worker raised a weight of 90 lbs. to a height of 18 inches 12,000 times a day, equal to 773 foot-tons ; a truly remarkable performance.

From Dr. Parkes' investigations he believed that 500 foot-tons a day to be an extremely hard day's work, which few men could continue to do, and that 300 foot-tons represented an average day's work for such workers ; whilst 400 foot-tons would be a hard day's work. These figures approximate to those given by other authorities ; thus Coulomb gave in foot-tons the following : for turning a winch 374, porters carrying goods and returning unladen 325, porters carrying wood upstairs and returning unloaded 381 ; Lamande gave for pile driving 352, and Haughton gave for paviors' work 352 foot-tons.

Relation between work done and Internal Work of the Human Machine.

Now these quantities of work are equivalent to what the engineer, in measuring the power of an engine,

calls effective work, but part of the total energy put into an engine in the form of steam, gas or oil, is consumed in doing internal work, so in the human machine (which may be regarded as an internal combustion engine, for this purpose), we have internal work done by the heart (that may continue to beat incessantly in alternating contraction and relaxation, throughout the man's life without any accumulated fatigue) muscles of respiration, digestion, &c., and this has been variously estimated: the estimate for the heart alone varying from 122 to 277 foot-tons, the former value is that given by Haughton, who estimated the respiratory movements as being equivalent to 11 foot-tons in twenty-four hours.

Dr. Parkes adopted a mean value of 260 foot-tons for all the internal mechanical work, and 300 to 500 foot-tons as the external work of a labourer of the type in question; and this he estimated was equivalent to from one-eighth to one-seventh of all the work obtainable from the food; this, strangely enough, giving an efficiency equal to that obtainable from a first-class modern steam engine, boiler, &c., from the fuel, as measured by the external work in each case.

Rest from Fatiguing Labour. Weber's and Taylor's Laws.

In heavy manual work periods of rest should be prescribed scientifically. *Weber's law* is that "our power of detecting differences between sensations does not depend on the absolute amount of difference in the stimuli, but on the relative amount." And as Dr. L. M. Gilbreth* explains, "the additional fatigue from handling additional weights causes fatigue to increase with the weight, but not in direct proportion to the extra weight handled. When the correct weight of the unit to be handled has been determined, the additional weight will cause fatigue in quantities greater in proportion than the extra weight handled."

**The Psychology of Management*, by Lillian M. Gilbreth, Ph.D., M.L.

Practically all heavy labouring work consists of a heavy push or pull on the man's arms, that is, the man's strength is exerted by either pushing or lifting something which he grasps in his hands. And *Taylor's law* is that for each given push or pull on the man's arms it is possible for the workman to be under load for only a definite percentage of the day. For example, when pig iron is being handled (each pig weighing 92 pounds), a first-class workman can only be under load 43 per cent. of the day. He must be entirely free from load during 57 per cent. of the day. And as the load becomes lighter, the percentage of the day under which the man can remain under load increases. So that, if the workman is handling a half-pig, weighing 46 pounds, he can then be under load 58 per cent. of the day, and only has rest during 42 per cent. As the weight grows lighter the man can remain under load during a larger and larger percentage of the day, until finally a load is reached which he can carry in his hands all day long without being tired out. When that point has been arrived at this law ceases to be useful as a guide to a labourer's endurance, and some other law must be found which indicates a man's capacity for work.

When a man is carrying a heavy weight in his hands it tries him about as much to stand still under the load as it does to walk with it, since his arm muscles are under the same severe tension whether he is moving or not, and the tissues of his arm muscles are in a process of degeneration ; so frequent periods of rest completely free from load are required in order that the blood may have a chance to restore these tissues to their normal condition.

Thus science prescribes rest for overcoming fatigue of the worker more accurately and economically than he could possibly provide it for himself, be the work heavy or light.

The most Efficient Length of Working Day.

The vexed question of what on the whole is the most efficient length of the working day has for years been

discussed, but it now demands serious attention. It is often suggested that it is to the interest of the employer that the working day should be as long as possible, and to the interest of the employee that it should as be short as possible, of course, provided always that the wages do not alter ; but, it cannot be denied that whilst too short a working day injures the employer, too long a one injures the employee : the problem is in all cases to find the golden mean that is equally advantageous to both parties.

Now, there cannot be a doubt that the best length of working day varies in different trades, and in the same trade under different conditions and circumstances ; thus workers engaged on light work or purely mechanical work in well ventilated and efficiently lighted shops can, for example, work longer hours with less fatigue than smelters or furnace men, who labour in a sweltering and vitiated atmosphere. Further, an industry carried on in a town may require a shorter day than a like industry located in the country ; but it is generally possible to determine scientifically by fatigue studies what length of working day is on the whole most advantageous to both parties in the circumstances ; best for the workers because it allows them to recuperate their strength day by day, and best also for the employer because he profits by the employees' increased capacity for work. It is true that shorter hours mean some loss to the employer due to the machinery running a shorter number of hours ; on the other hand, there is a saving effected in the expenditure on motive power.

Experiments on Shortening the Hours of Labour (Balancing).

Many interesting experiments have been made from time to time on the economic effect of shortening the length of the working day, and attention may be called to the one made in the Ziess optical works of Jena in the early part of the year 1900 ; and described by Dr. Auerbach :—

"The employees of the works were asked whether they thought themselves capable of, and were willing to do, as much work in eight hours as they had heretofore done in nine. Six-sevenths of the replies were in the affirmative, and as a consequence the working day was reduced, at first tentatively, for a year to eight hours. The result was satisfactory in the highest degree. An accurate comparison of the work done before and after the change could, for various reasons, be made, only in the cases of 233 pieceworkers. It was, however, found that in this instance the output so far from having diminished, had actually increased by 4 per cent.; notwithstanding that the conditions of work vary very considerably, the above result was found to be applicable to workers of all ages, and, with perhaps a single exception, to every department. At the same time the efficiency of the machinery was considerably increased. Still more interesting than the results of this statistical investigation were those of a psychological enquiry, which was carried out secretly, and which supplied evidence, the value of which was all the greater because the results in question, objectively considered were in opposition to the subjective feelings of the people concerned, and could not therefore have been influenced thereby. The workmen, when asked, invariably declared that in order to avoid loss they had worked very hard at first, after the introduction of the eight hours day, but they had been unable to keep up the pressure, and had fallen back into the old routine. They therefore wished to return to the nine hours day, as otherwise their position would be very unfavourably affected. The records, however, showed that whilst it was undoubtedly true that the workers had laboured for the first few days under abnormally high pressure and had then slowed down, they had, notwithstanding, ultimately accommodated themselves—not as they imagined, to their former hourly, but to the former daily output, doing in fact a little in excess of this. This showed that work under increased pressure, so long as the pressure is not so great as to lead to an increase in the daily output, does not produce over exertion."

The above is an excellent illustration of that adjustment of application to the length of the working day, and the maintenance of equilibrium between the development and expenditure of energy which is so often unconsciously made, and is referred to by writers on fatigue as balancing.

Two Shifts versus Three Shifts.

When for some good reason it becomes necessary to run a factory continuously, as is now done in many munition works, the vexed question of two shifts of

12 hours each versus three shifts of 8 hours each has to receive serious attention. Of course, in cases where it is necessary for a works to produce its maximum output, and the workers are available in sufficient number, the three shift arrangement would be adopted with the best results ; but in other cases, in which the maximum output per worker is aimed at, the decision as to which arrangement should be adopted would largely depend upon the character of the work done ; thus where output is controlled mainly by machines the twelve hours shift would probably be the best, as such work can generally be performed sufficiently well by tired men, but, as Professor Stanley Kent has found in his researches, "skilled work calling for judgment and discretion demands freshness and vigour" and for such work the highest efficiency would probably be reached in most cases by the adoption of the three shifts of 8 hours. Indeed, a manufacturing company in America, which keeps its factory going night and day found on changing from two shifts of 12 hours to three shifts of 8 hours each that the efficiency of the men gradually increased ; and the days lost per man by illness fell from $7\frac{1}{2}$ to $5\frac{1}{2}$ per year.

The Five Hours Spell.

In some factories working from 7 a.m. to 6 p.m. there is only one break of an hour for a meal from 12 to 1 p.m. This disposition of the hours, although legal, cannot be an economic one, as towards the end of each spell the fatigue must be pronounced ; indeed, there is growing evidence that to secure the highest efficiency we must pay far more attention to suitable rest periods, and reduce the hours of continuous labour.

Effect of Interest or Incentive on Output.

It is generally known that some kind of interest or incentive will increase the capacity for work of the ordinary worker ; it may be a bonus, or a share in the profits as a co-partner, that quite naturally spurs the worker to almost unconsciously increase his output ;

or the incentive might be so great that an astonishing amount of extra work will be done without any injurious fatigue being noticeable.

The writer had under observation some years ago a remarkable case of this kind ; a six o'clock man finishing his day's work as an erector at 5 o'clock, after having tea worked at a foot-lathe at home in a most strenuous way for some four or five hours each evening, and this he did for some months on end, without apparently suffering from fatigue, as the sign of fatigue is diminished output, and there was no evidence of that ; but in this case there was a very strong and worthy incentive to earn the extra money.

The psychology of such cases is referred to in the following paragraph from Memorandum No. 7 :*

"Interest may improve the working capacity even for a uniform monotonous activity, and the interest may spring from emotional states, or, as some think, from states of anticipatory pleasure before meal time and rest ('end-spurt'), or again, from a sense of patriotism eager to forward the munition output." This view is supported by Professor Kent, who remarks that "psychical influences affect output ; the output on Saturday, in spite of great fatigue, is often high, owing to anticipation of the week-end rest."

Unnecessary Fatigue in its Relation to Output.

The call for the suspension of trade union restrictions, to enable women to replace in our factories men engaged in the fighting forces, also the call for the fullest scope to be given to the principle of dilution of labour, have been met by the workers and their representatives in a most praiseworthy and patriotic spirit ; and now that the vexed and important questions of the most efficient working hours and the amount of overtime permissible are more or less settled for the time being, the question arises, is there any aspect of the general

**Industrial Fatigue and its Causes*, by the Health of Munition Workers Committee of the Ministry of Munitions (Cd. 8213, Price 1½d.).

subject of fatigue in its relation to production that has not received adequate attention. The answer can only be in the affirmative ; as apparently certain forms of waste, which in their broad comprehensive scope are among the most important factors in economic production, have not been considered by the authorities, although they have received some attention here and there.

Now unnecessary fatigue is largely due to waste motions, waste energy and waste time. Endless examples could be given, but let us consider a typical case, such as a worker engaged in assembling a small machine or any complete thing consisting of a number of separate parts. The traditional procedure is to surround the worker with a collection of the separate parts ; some may be in boxes lying about the bench others on the floor, the latter necessitating a bending action on the part of the worker each time a piece is required. Now in shops where science and method rule, all the component parts would be carefully arranged on well thought out frames and tables, placed in such positions in relation to the worker that he could reach each piece as it was required in proper sequence with the minimum amount of motion of any part of his body, therefore, with the minimum amount of fatigue and loss in time. A case in point is explained more in detail hereafter, in which an operator who formerly took $37\frac{1}{2}$ minutes to assemble a machine could do the same job in $8\frac{1}{2}$ minutes with less fatigue, after his movements and the operations had been organised.

Another striking example of quite unnecessary fatigue in a different branch of industry may be cited ; it occurs in fish curing operations in Scotland.* The bottoms of the "Farlanes" or troughs containing the fish are commonly on or near the level of the ground, so that women while employed in gutting are compelled almost continuously to bend their backs in a most uncomfortable fashion, the upper portion of the body forming nearly a right angle with the legs ; a

* Chief Inspector's Annual Report on Factories, &c., 1914, page 64.

back-breaking position from which they can only assume a vertical position at the cost of considerable pain. Who could doubt that the obvious remedy would increase the output, with less fatigue ?

Trifling Matters may Cause Fatigue.

Although the subject of industrial fatigue is a most comprehensive one, as we have seen, calling for careful study of the available literature and of the official publications previously detailed, to keep abreast of our present knowledge of it ; the history of fatigue work abounds in cases in which some trifling matter has been found to be the cause of fatigue, and in which the output has been materially increased by a slight adjustment, replacement or re-arrangement. For instance, a chair, bench or vice may be too high or too low for the worker ; a chair that is used hours on end may have an uncomfortable seat ; the worker's wearing apparel may not be easy fitting and comfortable ; the heels of the boots may be too high for a worker who has to stand for hours each day ; the shop or room may be draughty, or too cold, particularly at the floor level ; the lighting may be inefficient, and so on. In a word, it pays to do everything within reason to make a worker comfortable, without the suggestion of coddling.

High Cost of Materials due to Wasteful Methods.

The economic effect of the absence of method and organisation in relation to unnecessary fatiguing labour is felt in all directions where production is concerned. Examples without end could be given ; the following being typical of a certain class. In normal times enormous quantities of building sand are used in the London area, and its price is in the order of 10s. to 11s. per ton, a sum greatly exceeding what it should be, having regard to the value of the sand at the pits, or river bank, but when the antiquated methods of handling and transporting the material are examined it is not astonishing. The sand is shovelled into carts

at the pit, say at Luton, carted to the railway station and shot in a heap at the yard ; in due course it is shovelled into a railway truck, conveyed to the London yard, and again shot in a heap, from which it is again shovelled into the contractors' carts ; and well might we complain of the cost of our military and other building operations, and of the amount of unnecessary labour when our man power is being taxed to its limits.

The Science of Shovelling.

Then, further, quite apart from the cost of transport, little or no attention is given to the science of shovelling sand and other materials. Many years ago Taylor, by careful experiments, found that a first-class shoveller could do his best day's work, day in and day out, when the load on the shovel was about 21 pounds, and this led him to provide shovels of different sizes for different materials. He found that when a shoveller owned his own shovel he would frequently go from shovelling ore, with a load of about 30 pounds per shovel, to handling rice coal, with a load on the same shovel of less than four pounds. In the one case, he was so overloaded that it was impossible for him to do a full day's work, and in the other case he was so ridiculously under-loaded that it was manifestly impossible to even approximate a day's work.

Of course, there are other elements which go to make up the science of shovelling that cannot be dealt with here.

The Efficiency Engineer and the Economy of Scrapping.

Countless further examples could be given if space would allow ; indeed, turn in any direction we may, and examine the working conditions in any industry, but not necessarily every factory is a given industry, we find that the output could be increased, and in some cases tremendously increased, by scrapping antiquated machinery and methods, and replacing them by up-to-date plant, devices and methods. And this too with

less fatigue, and in some cases with fewer workers. Indeed, we must not close our eyes to the fact that in far too many works in all our industries there is a lamentable absence of enterprise, and apparently of clear-sighted appreciation of the economic value of modern machinery. Doubtless the difficulty experienced in procuring capital for industrial developments is the primary cause in many cases, but, be the cause whatever it may, we should ever keep before our minds the following reference to American enterprise made in the report of the Moseley Commission :—

“ The finest machine obtainable, the newest and most up-to-date appliances are used ; and a manufacturer will consign the whole of his plant to the scrap heap without remorse if he sees that newer and better machinery can be installed which will enable him to realise a larger output of work.”

But even in cases where, for one reason or another, modern machinery cannot be installed, the services of an efficiency engineer could be utilised with very great advantage in speeding up mechanical operations to an extent that the best practice has proved to be most efficient, and by organising improved methods of working to increase the output with less fatigue. Not the least potent of these would be in the direction of the dilution and sub-division of labour.

Dilution and Sub-division of Labour.

Among the problems relating to economic production that the war has forced upon the entire country is that of the dilution of labour, and the great developments that have taken place in this direction have conclusively shown that it offers one of the largest fields for economising labour. During the past decade or two there has been a steady increase in the division and sub-division of labour in large factories, increasing the amount of work that could properly fall to semi-skilled and unskilled labour ; yet in many trades the free expansion of this valuable economic principle has been greatly restricted by the trade unions, but owing to

the patriotic suspension of such restrictions where the manufacture of munitions is concerned we have had clearly demonstrated the possibilities of further economies in this direction.

Reclassification of Trades.

The fact is that many of our trades badly need sub-classifying and standardising, and if we are to hold our own after the war this must be seriously taken in hand. In fact, it will be one of the means of securing for our workers a continuation of the high rates of pay they are now enjoying ; indeed, if we energise, and improve our methods in this and other directions, there is no reason why our workers should not in the time to come enjoy even higher wages and a better social future, with shorter hours of labour in many cases.

The nation has immensely benefited by the labours of the Engineering Standards Committee during the past few years. A large number of things, from bolts and nuts to high-speed engines, have been standardised to our very great economic advantage ; but much still remains to be done, perhaps even to the extent of standardising certain types of ships.

Of course some trades more easily lend themselves to reclassification than others, but there can be no doubt that in all cases higher wages and lower production costs would be secured by a division of work into suitable classes, according to the muscle, brain, training and skill required ; the standards and wages of all classes would be raised, unnecessary waste would be eliminated, and disputes between capital and labour would tend to disappear.

Typical Scheme of Reclassification.

As an example of a well thought out scheme of reclassification, the one suggested by Mr. Frank Gilbreth --the famous consulting management engineer--for

brickwork, might be cited as indicating the lines along which we should work. He recommends five classes :—*

" CLASS A. Ornamental and exterior face brick and moulded terra cotta.

CLASS B. Interior face tiers that do not show at completion, where strong, plumb and straight work only is needed.

CLASS C. Filling tiers where only strength is needed.

CLASS D. Putting fountain trowels and brick packs on the wall near the place, and in a manner where the other three classes can reach them with greatest economy of motion.

CLASS E. Pack loaders, brick cutters, and stage builders.

The pay of the A. and B. Classes should be considerably higher than is customary for bricklayers. The pay of the C., D. and E. Classes should be lower than is customary for bricklayers, but much higher than the pay of labourers. This classification will raise the pay of all five classes higher than they could ever obtain in the classes that they would ordinarily work in under the present system, yet the resulting cost of the labour on brickwork would be much less, and each class would be raised in its standing and educated for better work and higher wages.

In the case of brickwork this new classification is a crying necessity, as the cost of brickwork must be reduced to a point where it can compete with concrete. Improvements in making, methods of mixing, transporting, and densifying concrete in the metal moulds of to-day have put the entire brickwork proposition where it can be used for looks only, because for strength, imperviousness, quickness of construction, lack of labour troubles, and low cost, brickwork cannot compete with concrete under present conditions."†

Those who are acquainted with Mr. Gilbreth's remarkable achievements will fully admit that there is probably no one better qualified to work out such a scheme of classification in the particular trade that he has dealt with above, a trade in which, owing to interesting circumstances, he felt called upon to devote his rare gifts in developing scientifically, and in doing this he proved that his methods were practically and commercially effective ; but revolutionary as his suggestions

* " Motion Study," page 96, published by Constable & Co. Ltd.

† Of course Mr. Gilbreth is referring to the practice in the U.S.A., but there is good reason to believe that they substantially apply to our own country.

must appear to most of our workers we must admit that they are the natural corollary of our dilution expedients, and that if we are wise we will spare no efforts in worrying out in all our important trades scientific classifications, and finally, forms of standardisation, for the good of all.

Management, Traditional and Scientific.

The science of management, as represented by the highest productive efficiency in labour, the highest degree of productivity for a given expenditure of materials, labour and the mechanical appliances utilised by labour ; with good dividends and high wages ; is a very complicated and difficult one ; but one that earns rich rewards to all concerned when tackled by the right type of men in the right spirit. A healthy and most promising sign of the times is the many references to "scientific management" which have appeared during the past year or two in our official publications. Thus we find in Memorandum No. 7, "The problem of scientific industrial management, dealing as it must with the human machine, is fundamentally a problem of industrial fatigue."

Now this important truth could not have been better stated, for the interests of the employers and workers being identical, any well organised system of management that has for its object the saving of energy, time and materials ; with higher wages for the workers and lower labour costs for the employers ; a system so well thought out that in producing a certain article leaks can be detected by suitable diagnosis so that the production may be the most efficient and economical, is entitled to be called scientific.

But whether the system adopted be called scientific management, or scientific administration (as Sir William Lever suggests we should call it) is a question that does not call for immediate decision so long as science guides our activities. Unfortunately, many employers fight shy of the word scientific, although they may be using good up-to-date methods, and some form of " premium

plan," which is a fundamental of Taylor's system of scientific management that has been so completely elaborated in the United States, and gives such wonderful results to all concerned where it has been intelligently adopted.

Restriction of Output.

Unfortunately, one of the most serious difficulties arising in the employment of labour is the reluctance of the majority of employees to work to the best of their ability. They feel, in the first place, that if they work hard they may be keeping another man out of a job, a widespread fallacy; as even from the purely personal view of the wage-earner this policy is short-sighted, because the production of wealth is itself the only means of creating employment; for in the long run a workman can only be paid out of the product of his own labour, and if that product is restricted the wage will be restricted also; further, employees feel that by turning out their work in a shorter space of time they may be establishing a basis for a lower rate of pay.

There is, it is true, some foundation for this fear, as undoubtedly there are foremen and employers who will take advantage of a man's exceptional efforts and reduce the scale of payment. The knowledge that this does happen explains to a large extent the reluctance of many workmen to work at their highest efficiency, and to some extent to the adoption of the infamous soldiering or ca-canny methods, now happily being to a great extent abandoned for the higher standard; but the false economic and the false moral theories upon which the policy of restricting output is based have done in the past incalculable harm.

Remedy for Restriction.

In seeking for a satisfactory remedy for restriction we must go a little further, and endeavour to find the root cause. Now it does not require a profound knowledge of human nature to understand that the fear of unemployment must be constantly before the minds

of workers who are family men ; and believing, as many of them do, that a fixed quantity of work is to be done, they oppose speeding-up methods, and the introduction of labour-saving machinery and appliances. The fact that improved methods and speeding-up are going to cheapen production and increase the demand, thereby increasing the demand for labour, is no consolation to the worker who is likely to be thrown temporarily out of employment, and it is this deep-rooted and well founded fear on the part of the worker that he may lose his job that after all is the basic cause of restriction. So, if we are to permanently abolish restriction it would appear that we must so organise our industries that the employees who work to the best of their ability may be reasonably free from such anxieties.

Scientific Methods in Management.

There is, however, a third cause of inefficient labour and low production which in this country has received nothing like the attention it deserves ; namely, the fact that the actual method of working is too often left entirely to the worker himself, on the traditional "go as you please" day's work plan ; and he is often so poorly equipped on the technical side that he cannot plan out the most efficient way of doing his own work. Now in scientific management an official of the planning department (called in America a route clerk) a man of the foreman type with an expert knowledge of the work and the machinery used to produce it ; especially selected and trained to plan and analyse all work, methods, &c., issues complete instructions to the workers, instead of such important matters being left to be decided by the skilled mechanics, who are well qualified to work at their trades, but poorly trained for work of a more or less clerical type.

We may consider an illustration of how this arrangement works ; let us take the case of an engineering machine-tool shop. For each piece to be machined an instruction card is issued from the planning department, on which there is usually a dimensioned sketch

of the piece ; and detailed instructions of the sequence of the operations, with particulars of the tool to be used, depth of cut, feed, cutting speed, the time each operation should take (as determined by accurate measurement or experiment), and the total time, given. Thus, when an order reaches a worker every detail has been provided for, he has no questions to ask ; the proper tools are placed beside him, and the materials themselves are conveniently near at hand, so his output is proportionately increased, as all his time is spent on productive labour. If a man follows such instructions and accomplishes all the work laid out for him as constituting his proper task for the day, he is, by the task and bonus system, paid a specified bonus, in addition to his day's rate, which he always gets. But **in no shop operating under scientific management is a piece rate once set ever "cut,"** so long as the operations remain unchanged.

It should be explained that there are many forms of management formulated and in use that do not conform to the laws of management as discovered by Dr. Taylor ; but his management, founded upon time study, is the basis for all scientific management ; that is for types of management where scientific laboratory methods of analysis are substituted for the traditional "rule of thumb methods."

A Secret of Germany's Remarkable Industrial Progress.

It should be generally known that one of the secrets of Germany's wonderful industrial progress during the past quarter of a century is that in her larger works the instruction card methods of increasing output have been freely used. It is true that in more recent years the science of management has been greatly advanced in America, primarily due to the labours of Taylor, Gilbreth, Gantt and others, and that day by day more attention is given to it, but the Germans have been clever enough to utilise the services of the best American brains, although probably they would not admit it.

Marvels of Waste Prevention. Increased Output by Less Work.

The attention now focussed upon fatigue may help us to realise that no industrial opportunity offers a richer return than the elimination of needless motions, and transformation of ill-directed and ineffective motions into efficient activity; for in Mr. Frank Gilbreth's words "the greatest saving in time, money and in energy will result when the motions of every individual, no matter what his work may be, have been studied and standardised." And, it may be added, when the question of fatigue is so well understood that every worker will get the rest required for overcoming it without calling upon his reserve of strength.

To give some idea of what is possible in this direction, when proper micro-motion and time-studies have been made and utilised, the following marvels of waste prevention and time saving due to the genius of Mr. Gilbreth may be briefly quoted :—

In Bricklaying, the motions have been reduced from 18 to 5 and the output increased from 125 to 350 per hour.

In Cloth-folding, 20 to 30 motions have been reduced to 10 or 12, and the output increased from 150 to 400 dozen, with no added labour.

Putting Paper on Shoe Polish.—The time was halved, with less effort.

Assembling Braiding Machines.—One man assembled 18 in a day, but this was increased to 66, with no increase in fatigue.

Typewriting.—After a motion study analysis of machine and operator, the typist entered the annual speed contest at New York, and defeated the International Champion by writing the unheard of gross of 147 words per minute for the entire contest, and 137 words net (5 words deducted from the gross for each error in spelling or spacing) per minute for the entire contest, winning the 1st prize. The gross exceeding by 5 words per minute anything ever heard of in the history of the art of typewriting.

Thus we see what is possible when science is called in to act her part, as by using the cinematograph, motions quicker than the eye can follow may be magnified, picked to pieces and analysed, as a microscope enlarges an organism and enables us to study and analyse it.

A Motion Study.

An interesting case was described more in detail a year or two ago in "Factory," a Chicago journal :— Two men were assembling a machine ; one was taking $37\frac{1}{2}$ minutes to do the job, the other 40 minutes to do the same job. The movements of the men were so rapid that no difference could be detected by the most expert observer, so a special split-second clock, with a rapidly revolving second hand was set by each of the men, and motion pictures were taken of them at work. The resulting films were thrown on a screen at a much reduced speed and carefully studied. Frames and tables were then invented to eliminate motions which took up the smallest fraction of a second, until finally the operator who formerly took $37\frac{1}{2}$ minutes to assemble his machine could do the same job in $8\frac{1}{2}$ minutes.

The movements of the human machine are never so accurate and methodical as those of a machine, skilfully designed to perform some definite operation. The fact is that although we teach children how to correctly and efficiently use their knives, forks, and pens, &c., we do not take anything like the same amount of trouble to train the movements of our workers so that they may reach their highest efficiency. This can only be done in the fullest degree by adopting motion study methods. To understand how far our movements fall short of mechanical precision, we should examine the working of textile machinery and see how by the use of cams, levers, &c., all the multifarious movements are made with mathematical precision, without waste motions or the least loss of time. So, when the movements of the human machine are organised by cutting out all redundant motions and arranging a more efficient

order of operations, the output can be greatly increased with less fatigue.

Hope for Disabled Soldiers.

Fatigue work is going to do a great deal to assist our splendid heroes—who have been maimed—to become self-supporting; indeed, much is being done already in America and Canada. It is not enough to utilise all the mechanical ingenuity available to invent expedients, appliances, devices and machinery by means of which one hand may be able to do the work ordinarily done by two, a great deal has been done in this direction in our own country, mainly due to the organising powers of Major Robert Mitchell;* indeed, in all the warring countries remarkable developments are taking place, particularly in France, where the genius of our good friends—of the famous scientist, Dr. Jules Amar, in particular—is working wonders. No, we must progress a good deal beyond that, and endeavour by suitable studies to eliminate all the purposeless motions and correct the awkward ones of the different parts of the useful limb, so that its highest efficiency may be reached.

There are two methods of attacking the general problem.

The Two Methods of Attacking the Problem of Disablement.

Mr. Gilbreth aptly explains that there are two distinct methods of attacking the problem, both valuable, the two being supplementary to one another.

The European method is exemplified by the work of Professor Jules Amar, who in typical papers, considers the device or contrivance that the cripple is to use as the fixed element, and adapts and equips each cripple so that he can use the devices of his trade, or of the new work that he has chosen to do.

*See a paper on *What can be done to train Disabled Sailors and Soldiers in Technical Institutions*, read before the Association of Technical Institutions, October, 1916. And a paper on *The Problem of the Disabled Soldiers and Sailors*, read before the London School of Economics, November 1st, 1916.

The typical American attitude is, perhaps, exemplified by the work done in the United States in considering the cripple as the fixed element, and adapting the device and method to the individual cripple who is to use it. It is but natural that the first method should be used in Europe, where many of the labour-saving devices in use have come from America and cannot be easily adapted. And it is as natural that the American methods should be in use in the United States, where the devices are more easily changed—to suit individual workers—by the original makers of the machines.

The subject is beyond the scope of this article,* but reference may be made to two cases that are typical of what can be done ; they have both been motion studied by the writer's friend Gilbreth. The first is the use of a magnetic hammer, in nailing boxes, to pick up the nails, arranged in suitable spaces on a board or in a box, heads upwards, so that adhering to the hammer-head the nails may be driven in where required, using one hand only. This has been a complete success, as after training it was found that a one-armed man easily exceeded the normal output of a man working in the ordinary way.

The second case, particulars of which have just come to hand, bids fair to open up a wide field of employment as typewriters for those who have lost an arm. Rolls of paper and ribbon are attached to the wall, machine, or a suitable support, obviating the necessity of putting the separate sheets in the typewriter ; and four copies can be made at once when necessary. It is true that the paper has to be torn off after each letter is written, leaving a rough edge, but it is believed that the public will not mind receiving letters with torn edges when they know that the crippled soldier has had a chance of earning a living.

*Refer to Mr. Frank Gilbreth's paper on *Motion Study for the Crippled Soldier*, read before the American Society of Mechanical Engineers, October, 1915: also *Motion Study for the Crippled Soldier*, American Association for the Advancement of Science, 1915: and *How to put the Crippled Soldier on the Pay Roll*, the Economic Psychology Association, New York, January, 1917.

Use of Time Studies in Increasing Output.

Time studies, which are complementary to motion studies, are required in establishing standards which must be lived up to by the worker. They also enable us to measure the relative efficiency of old and new methods. In making time studies the "decimal" stop-watch is used, the minute or outer circle being divided into a hundred parts; a small dial registers minutes, and the watch is arranged to be stopped and started with the thumb of the left hand. If an observation has been taken and the watch stopped, say at 1.32 minutes, it can be started again on a second observation which adds to the first; or if it is desired to throw back the hands to zero before taking the second observation, so that it only will be registered, a pressure of the forefinger on the stem is necessary.

The time-study man must be skilled in the trade under investigation, with sound judgment, patience and an open mind; his powers of observation must be well developed and he must be exact, tactful and diplomatic. He should also be well trained in silent rhythmic counting, as often useful observations can be taken in this way, where the production of a stop watch would alarm the worker or make him nervous.

Iron Plate Punching Timed.

The art of making ordinary time studies cannot be explained in a few words, but sometimes the output can be increased by a very elementary application of the art. A case in point may be cited, in which the study was made not primarily to demonstrate to the satisfaction of the management that the time used to perform a certain job could be shortened, but rather to give information to the workman himself. The component operations in iron plate punching were timed. It was found that the workman took four times as many seconds for a certain operation in the case of one plate as for the same operation on a preceding plate, or, say, 20 seconds, as against 5 seconds. Other variations were noticed in the analysis of the job, the

observation extending over several hours. Then the minimum times were added ; this total representing the time in which a plate could be punched in the various places called for if the workman performed each fractional operation in the best time he had made, working in his accustomed way.

It was a surprise to the workman to be told that such inequalities existed in the time he took for the simple operations. The proposal was made that if he finished within an hour a certain indicated number of plates—a number which the analysis of his own motions had shown he could finish, with a margin of time left—he would be given a considerable advance over the rate he was receiving. There was no unwillingness to make the attempt, and the increased output that resulted was continuously profitable both to the management and the man.

Time saving of this sort, resulting from a close study of manual operations, is typical of a great deal that could be done in an enormous number of works in which no attempts have been made to organise them to be run on modern lines. Such saving is not due to the application of the spur or to the driving of an unwilling worker ; it is rather the bringing out of information not available before and making it serviceable to the worker and his employer. Viewed in that light and carried out with tact, such methods of checking waste, increasing output and reducing fatigue, ought to win their way without forcing or friction.

Speeding Up Machine Tools.

The art of cutting metals has been reduced to a science by the labours of Dr. Taylor and Dr. Nicholson, and with modern machine tools, specially designed for using high speed cutting tools, the output has been enormously increased ; but in all but the best organised shops it is doubtful whether anything like the possible output is reached. In most cases the services of a properly qualified young efficiency engineer using suitable slide rules, of the Barth time and slide type, could

speed up the machine tools so as to materially increase production, and he would be available to report to the manager upon such matters as the following :—Whether skilled men were engaged a large part of their time in doing unskilled work? Whether any of the machines are so far out of date or repair that they should be replaced by others? Will it pay to put in automatic machines for some of the work? Should the premium system of paying labour be instituted in any part of the works for the part piece work and part day work that may be in use; and so on. In cases where such matters as these receive proper attention, and methods and machinery are improved, the output is increased and the employer is able to pay high wages.

The Importance of Efficient Welfare Work.

Looking back upon the conditions under which work was done in most of our factories three or four decades ago, and comparing them with those which characterise many of the well organised factories of to-day, we may well wonder how in former times we got along as well as we did. In those days it was apparently not realised that the efficiency of the worker, and his value as a producer very much depended upon his being able to work under comfortable, healthy and self-respecting conditions. Commencing work at six o'clock in the morning, the worker would, as a rule, in the winter enter a cold, draughty, badly lighted shop, and, strive as he often did, the conditions were such that, with cold hands and feet, and a general feeling of discomfort, proper working efficiency was impossible. Wash rooms were unthought of in those days, and the lavatory accommodation often filthy, whilst a drink of pure water was usually unobtainable; indeed, strange as it may appear to many, in some works, where the greatest pains were taken to work the machinery at its highest efficiency, the human machines, the most sensitive and expensive units, were left to the care of themselves, with little or no thought for their comfort and well-being. But happily such ignorant shortsightedness is

to a large extent a matter of the past, and for some years the more enlightened and enterprising employers have been keenly alive to the direct and indirect advantages of doing all that is possible to arrange for good working conditions inside and outside their works, in order to promote the well-being of their workers generally by proper welfare supervision. Indeed, such care for the workers is found to pay well in the long run, and not a few employers organise such activities on the ground that welfare work is a vital and integral part of the management of their factories, to be shared in by all concerned, directors, managers, foremen and workers, as well as by the welfare supervisor. There is indeed much to hope for, as this salutary movement is growing apace, and we should not rest until—apart from the question of health—the provision of proper conveniences and conditions for the comfort and welfare of the workers is considered as a necessary part of the organisation of every factory, without the slightest suggestion of coddling, which every decent worker resents.

The Housing Question.

Capital can never expect to get the best out of Labour until the vexed housing question is seriously tackled. The housing conditions that exist in most of our crowded industrial districts is little short of a public scandal in these enlightened days ; and there is no reason to doubt that not a little of the intemperance and crime, that in their cumulative effects are so damaging to our productive powers and the well-being of the State, are directly attributable to the absence of comfortable and decent surroundings in the homes of a large proportion of the workers.

As we have seen, discomfort in the home is a direct cause of one phase of industrial fatigue, it represents to a large extent the kind of fatigue which is brought to the job, and the Nation can never hope to secure maximum output from Labour, until the housing problem is solved. It is beyond the scope of these

articles to touch further upon the matter, the root cause of many of our industrial troubles, but it may be remarked, that much has been done in the right direction by the centrifugal removal of not a few works from central London, and from other cities and large towns, to outlying districts. There the erection, near the works in more or less open country, of suitable cottages with gardens, enable the workers and their children to live in decency with health-giving surroundings. The housing problem is one of paramount importance, as apart from its bearing on industrial efficiency, we can never hope to greatly reduce the appalling wastage of child life until it is solved.

Welfare Supervision.

As might be expected, the enormous increase in the number and size of our factories and works due to war requirements, and the necessity of organising a large army of good and true industrial workers, has prominently brought to the front the question of welfare work ; and, as we have seen, the "Health of Munition Workers' Committee" published in December, 1915, a Memorandum,* No. 2, entitled "Welfare Supervision," containing seven pages of instructive matter that should be in the hands of every worker and every employer. The duties of welfare supervision are to some extent defined, and may be conveniently quoted.

The Duties of Welfare Supervision.

We are told in the Memorandum that the duties of Welfare Supervision should include the following :—

1. To be in close touch with the engagement of new labour, or, when desired, to engage labour.
2. To keep a register of available houses and lodgings ; to inform the Management when housing accommodation is inadequate ; and to render assistance to workers seeking accommodation.

3. To ascertain the means of transit used, and the length of time spent in travelling ; to indicate the need of increased train, tram, or motor service ; or to suggest modification of factory hours to meet existing means of transit.

4. To advise and assist workers in regard to feeding arrangements ; to investigate the need for provision of canteen facilities, or any inadequacy in the provision already made ; and to supervise the management of such canteens.

5. To investigate records of sickness and broken time arising therefrom ; and in cases of sickness to visit, where desired, the homes of the workers.

6. To investigate, and advise in cases of slow and inefficient work, or incapacity, arising from conditions of health, fatigue or physical strain.

7. To consider, particularly for delicate and young workers, all questions of sanitation and hygiene affecting health and physical efficiency, and to supervise the conditions of night work, Sunday work, long hours, and overtime.

8. To advise on the means of recreation and educational work.

9. To investigate complaints and assist in the maintenance of proper discipline and good order.

10. To keep in touch with responsible organisations having for their object the promotion of the welfare of the worker.

Desirable Additions to the above.

In drawing up the above instructions, which were not put forward as complete, doubtless the special needs of munition workers were kept in view, but obviously the suggestions or instructions do not go far enough for more permanent industrial workers, if every reasonable thing is to be done to promote their efficiency and secure maximum output. This being so, the writer would like to see, in the best interests of both Capital

and Labour, the following included in the recognised details of welfare work :—

1. To introduce new workers to their foremen, to their fellow workers and surroundings.
2. To advance money or meal tickets to new workers short of funds.
3. To report on inadequacy of light, heat and ventilation.
4. To report on abnormal noise, dirt and noxious odours and fumes.
5. To see that lockers are provided to hold overalls, and a pair of dry boots.
6. To see that proper provision is made for the drying of clothes.
7. To see that lubricating and cooling fluids for machine tools contain a small amount of some antiseptic, such as carbolic acid, say, up to about 1 per cent., to prevent the occurrence of eczema.
8. To see that a proper supply of pure drinking water is available for all workers.
9. To see that proper wash rooms, with hot water, are provided, and to encourage workers to use clean overalls.
10. To see that sanitary lavatories are provided and that they are decently private.
11. To see that facilities for the prompt treatment of all cases of sickness and injury are available, particularly where dangerous machinery and poisonous substances are used.
12. To arrange for doctors and nurses to visit, when desired, those kept at home by illness.
13. To provide the services of an oculist and dentist to ensure workers having good sight and good teeth.
14. To investigate causes of absence without leave.

15. To arrange for annual holidays with pay for all workers of nearly a year's standing, on a basis of efficiency and punctuality records.

16. To sympathetically hear complaints at all times ; however they may be put forward.

17. To encourage workers to improve their general and technical education by reimbursing them for outlay on courses of study satisfactorily completed.

18. To discover ambitions of workers—particularly the younger ones—for future transfer and promotion.

19. To advise on matters relating to the future of all workers and encourage the formation of thrift and co-operative societies and pension, house building and life assurance schemes.

Such comprehensive improvements for the comfort and well being of workers as those outlined above will make many employers gasp if they have not kept in touch with the trend of welfare work, and with what is being done in this direction by the most advanced employers in this country and in America. Although it is doubtful whether all that has been drafted above represents the activities of the welfare department of any one works, practically everything that is suggested is a feature of welfare work in some factory or another.

Of course, anything like a full scheme of welfare work is only practicable in a fairly large works, but it is astonishing what can be done for the wellbeing of the workers in any factory, if all concerned are infused with the right spirit of give and take.

Any good measure of welfare work costs a good deal of money one way and another, and economic laws are inexorable, so that if employers do much to maintain and conserve the good health of their workers, and to make the conditions under which they labour as comfortable as practicable, it is only fair that the workers on their part should do a good day's work, day in, day out ; this does not mean great physical exertion, but continuous and reasonable effort during the working

hours, and nothing short of this will ensure maximum production—upon which good general trade is dependent—and the payment of high wages.

Economic Loss due to the Mobility of Labour.

There comes a time when most workers aim at securing permanent employment, or at least reasonable security of employment, and it is only natural that openings are sought where the work and surroundings are agreeable and good money can be earned, with perhaps prospects of promotion. Such men are usually good time-keepers and reliable efficient workers, and as such become valuable assets in any works. On the other hand, there are workers, who for one reason or another, never remain very long in any works, shifting about from job to job ; perhaps failing here and there to give satisfaction due to want of skill, poor capacity for work or unreliability ; or it may be failure to work amicably with the foreman due to faults on one side or the other. Another fruitful cause of such changes of employment is due to want of care on the part of the foreman in engaging the men ; often this is done very hurriedly : a man is wanted for a certain job, and the first likely one that comes along is set on, only perhaps to prove his unfitness for the work after a good deal of time and perhaps material has been wasted in efforts to break him in.

Labour Turnover.

Now this wastage, due to what is called **Labour Turnover**, is very great in most works of any importance. How great apparently no one seems to know, and, strangely enough, great as it undoubtedly is, it represents an economic industrial factor that does not appear to have received any direct attention in this country worth speaking about. Apart from the fact that this loss is not a little due to want of care in selecting suitable men, it is without a doubt intimately related to the welfare movement in its broadest sphere ;

and it is a factor of the first degree in the general problem of the economical maximum output of any works.

Fortunately, our good friends in America have taken the question in hand, and a distinguished engineer, Mr. Boyd Fisher, Vice-President of "The Executive Club" of Detroit, Michigan, recently gave a most admirable Address* on "How to Reduce Labour Turnover." Mr. Boyd Fisher's Address is a very convincing one; it forcibly arrests attention to a matter of first importance to the parallel interests of Capital and Labour, and accentuates an important factor in the science of management. The Address should be widely read, certainly by all interested in the grave post-war industrial problems we shall have to face. To enable us to form some idea of the cost of exchange of employees, Mr. Magnus Alexander's estimate is quoted, it is that "it costs nearly £15 to break in a new semi-skilled operative." Of course that figure refers to America, where wages are much higher than in this country. But a better comparison with our own conditions can be made, and we may be spurred into action by noting what Mr. Boyd Fisher says about the Packard Employment Department, one of the oldest and best conducted in Detroit. "It has already effected vast savings in cost of turnover and yet the head of the Standard department, the man who, with his assistants sets all standard working times in the plant, estimates that new and inexperienced workmen reduce the speed of production so much that a 25 per cent. allowance of equipment, buildings, direction, labour and supervision must be made."

Employment Departments.

Such a well authenticated case, showing the heavy cost of labour turnover, should certainly start us

*Before the Philadelphia Association for the Discussion of Employment Problems, on January 9th, 1917. Before the Employment Managers' Association at Boston, Mass., January 9th, 1917, and The Employment Managers' Group, The Industrial Management Council of the Chamber of Commerce, at Rochester, New York, January 11th, 1917.

thinking seriously, but we may with much advantage consider the opinions formed by Mr. Fisher as to how we may hope to reduce the serious loss. He rightly attaches great importance to the care which should be taken in selecting men, and believes that every works of importance should have an employment department to deal with the engaging and discharging of workers, rather than allow foremen to do their own hiring and firing. An analysis of 57 Detroit plants made by Mr. Fisher shows that, "roughly averaged, the plants having an employment department hired two men to every three hired by those which did not have the employment department."

Inefficient Labour.

Mr. Fisher tells us that Detroit employers recognise that "turnover of labour is a special phase of the problem of inefficient labour, and that the reduction of turnover is only the first step in a process of education and of economic pressure to elevate the standards of workmen. They aim not only to keep workmen but to develop them. And they are prepared to go as far as the workmen's own home-life, even, to solve their problem."

So Mr. Fisher truly says, "turnover breeds inefficiency, inefficiency breeds turnover, and the only way to break the vicious circle is to attack them both at the same time, and, for the most part outside of direct factory activities."

We have seen that a particular phase of industrial fatigue is due to the way the worker spends his time whilst away from his work, and it is interesting to note that Mr. Fisher believes that "80 per cent. of the turnover of labour is due to causes that lie outside of direct plant activities; that is, when the workman is off duty."

Hasty Discharges of Workmen.

Industrial history, it has been truly said, is not particularly flattering to employers, and among many

labour grievances, more or less reasonable, that have led to trouble, workers rightly resent what might appear to be arbitrary firing on the part of foremen, who may be very capable men, but who are sometimes lacking in tact, good temper and the art of managing men. So that Mr. Fisher's suggestion that every discharge should be certified to by a Committee on which workmen are represented is one that deserves earnest attention in works where good and fair feelings prevail between employers and workmen. "Hire men wisely," says Mr. Fisher, "provide them with steady work at an adequate wage, and refrain from hasty discharges, your turnover will be comparatively low."

The Labour Turnover Problem.

The more the labour turnover problem in all our industries is looked into, the more important it will probably appear, and the more serious the attention it will demand on the part of employers and of the State. The maximum output of a works is directly dependent upon the efficiency of all the workers, and such efficiency on the part of many will depend upon the standard of the remedies we are wise enough to provide ; that they should be remedies that would aim at improving the health and fitness of workers and tend to organise their brains, goes without saying, but the right kind of remedies cost a good deal of money ; and wise we (as represented by the State) would be if we judiciously and freely invested money in this direction to supplement the enterprise of employers in conserving the health, the working capacity, nay, even the lives of the Nation's most valuable assets. In short, the remedies are intimately related to welfare work and education.

The cost of any comprehensive scheme for the reclamation (in the best meaning of the word) of Labour and the reduction of waste in labouring power would be great, and Mr. Boyd Fisher has no delusions as to the financial aspect of the problem, for he tells us that

"the thorough-going remedies for turnover are so expensive that until even the most sceptical managers are convinced we shall not get far with our corrective measures."

Scientific (or Methodical) Management.

The substitution of scientific management (as it is understood in the U.S.) for traditional management in any given works is not an easy matter, and cannot be more fully dealt with here, but it may be explained that there are a great many works in which by a little rearrangement some of the best features we have referred to could be introduced with considerable economic advantage to all concerned, giving a greatly increased output, with less fatigue and least waste.

Elements of Scientific Management.

Briefly, the following are the important elements of the modern systems of scientific management associated with the name of the late Mr. Frederick W. Taylor :—

1. A careful study of the time required to do the work. The Rate once set is never cut.
2. Detailing instructions to the men, telling them how they are to do their work. And the preparation of tools, tackle, etc., required for the work.
3. The thorough standardisation of all details which affect the speed of the work and the speeding up of all machine tools to their highest efficiency.
4. The payment of a premium for success, usually with a minimum wage.
5. An efficient administration for dealing with all matters relating to finance, accounts, statistics, factory economics, purchase of materials, sale of products, and new developments.
6. An efficient employment department for dealing with all such matters as engaging and discharging hands, complaints and suggestions of workmen,

methods of training apprentices and improvers, promotions, classification and records of workers, and welfare work generally.

After the War Problems.

Sir William H. Lever, Bart., in an admirable address on "Industrial Administration" recently given in Liverpool, told his audience that "when peace comes, bringing us victory over our enemies and giving us rest from the clash of arms, we shall still have to enter the field of struggle for commercial position amongst the nations of the world. It is unthinkable that we and our Allies proving victorious in this cruel war fighting for right and liberty, justice and freedom, should be defeated in the struggle for industrial position by our present enemies and neutral nations. And yet defeat is certain if our industrial organisation is founded on attempted oppression of labour on the one hand, or restriction of output by labour on the other hand."

Now these words of wisdom, coming from a fine patriot and a great Captain of Industry, should be seriously considered by all who love their country and are ready to do their bit in securing its industrial supremacy. But we must all pull together, which should not be a difficult matter with the new spirit that is abroad in the land. Indeed, no one who has been privileged to work with, to manage, or to teach the artisans of this country, and who understands them and their psychology, could fail to have a profound respect for them. They are in the main sensible, intelligent men, and many of them who have made good use of their spare time are cultured and extremely well educated; indeed, the late Mr. Mundella, when Vice-President of the Board of Education, said, at a prize distribution, that he knew many working men who would grace any gentleman's drawing room.

Of course, there are misguided fools among our workers who are easily led by those who hold mistaken views

about industrial matters and economics, but so there are in all classes of society.

Everything will be changed after the war ; we are passing through the cleansing fires, and the comradeship in arms of all classes will make us more human, and will assuredly bring with it a new spirit of unity in industrial relationships. In the past we have too much neglected the human element, we have not understood the true meaning of the great Suvoroff's apothegm "successful fighting is the correct utilisation of human nature."

Unlimited Industrial Expansion.

We have all the essentials for unlimited industrial expansion, if they are only properly engineered and utilised ; unexcelled human material, brain, energy, skill and brawn in the world ; we have coal power, iron power, organising power, shipping power, and the necessary machinery, or means to produce or procure it, to enable us to conquer and hold the open foreign markets of the world ; but to do this our workers and employers must be more amicably accommodating, and we must produce and distribute more cheaply and manage with greater skill and intelligence than other countries.

Further, if we fully utilise our engineering genius and enterprise to produce suitable machinery to enable us, with the assistance of the agricultural chemist, the agricultural botanist and the veterinary specialist, to revolutionise on intensive lines our agriculture, which is still our greatest industry, there would be an enormous outlet for the products of our engineering works in the home market, and we could double or treble the output from the land. Further, the plant that is now daily producing some $1\frac{3}{4}$ million gallons of alcohol for explosives could be utilised for the production of denatured alcohol for agricultural motor tractors, &c., making us independent of a foreign fuel for such purposes. All this is well within the range of practical politics, and no worker need earn less than his present

high wage if he is willing to do the best that is in him under methodical and scientific conditions of working.

Urgent Problems awaiting Solution.

When peace comes we shall be faced with gigantic social and economic problems which will demand sagacious attention, for on one hand there will be millions of industrial workers gradually released from military service, and on the other hand, we shall have the factories, distilleries and machinery that have been put down by the State for the manufacture of munitions, &c., costing tens of millions of pounds, no longer needed for the production of warlike articles ; and some millions of workers at present engaged, at higher wages than they have ever received before, in producing things that will no longer be required.

Now, as it is unthinkable that the national (and controlled) factories, distilleries, and machinery should be scrapped, these problems will take a good deal of time to satisfactorily solve ; and we must not have bitter cause to remember the saying of Napoleon, that " it is in human nature not to bother about even the most pressing necessities until some absolutely urgent need arises compelling action, and then it is just too late." No, we must cultivate the long vision, and see to it that some of our great statesmen, engineers and industrials, who are not now fully employed on matters of national interest, are appointed to carefully examine, tackle and solve these pressing problems whilst there is time.

Conclusions.

There are forces silently and inexorably operating, the trend of which is in the direction of the State taking such a controlling part in the management of many of our most important industries that was undreamt of in pre-war times. But whatever changes may come about due to the evolution of things we shall all rightly be called upon to work to the best of our ability. On

the other hand, our workers must have a square deal that will yield them an adequate return for their labour and proper time for rest and reasonable recreation. In short, to secure maximum production, a careful examination of all the factors that matter leads to the conclusion that we must so organise our industries that,

(a) the number of working hours, and periods of rest, if any, are so carefully adjusted in the different trades that the workers' health is not impaired by fatigue, and that he has proper time for rest and reasonable recreation ;

(b) the workers have a suitable incentive, and are not in constant fear that if they work to the best of their ability they may so increase their output that unemployment may ensue without reasonable notice ;

(c) every ounce of effort on the part of the workers is profitably utilised during the working hours for productive purposes, without over exertion.

(d) waste of every kind shall be either eliminated or reduced to the minimum.

(e) When the economic conditions are favourable the most modern and efficient labour saving machinery, implements, tools and devices are used at their highest efficiency.

(f) That the well-being of all the workers is cared for by an efficient employment department.

Whether these conditions can be best realised by a great extension of the beneficial and equitable system of Co-partnership, or through a more general adoption of any of the systems that offer a fair incentive and reward, or through some system in which there is Co-partnership and bonuses, remains to be seen.

But whatever system be most favoured, let us rouse our sense of responsibility and improve the output of our industries, with a fuller and brighter life for our workers ; that the output can be greatly improved we have seen ; how greatly it is impossible to predict, but there can be no reasonable doubt that our future great

burdens will be lightly carried if science, system, strenuous efforts, economy, wide sympathies, and goodwill prevail.

Further, as the Empire is practically self-sustaining so far as raw materials and foodstuffs are concerned, let us amicably work and co-operate in a fraternal spirit with our fellow citizens of the Empire in the development and utilisation of these illimitable resources. If we are wise enough to do this, and continue to be animated by the high ideals we are fighting for, the Empire can with certainty and with worthy pride look forward to a future of boundless splendour.



THE OBJECT OF THE Labour Co-partnership Association.

THE object of the Association is to bring about an organisation of Industry based on the principle of Labour Co-partnership ; that is to say, a system in which all those engaged shall share in the profits, capital, control, and responsibility. With this view it seeks (1) in the Co-operative Movement to aid by its propaganda and advice all forms of production based on the above principles ; (2) in other businesses to induce employers and employed to adopt schemes of profit-sharing and investment tending in the same direction.

The Co-partnership of Labour with Capital is capable of many modifications according to the needs of varying industries, and in some one of them it is applicable to almost every industry where labour is employed. In its simplest form it involves :—

1. That the worker should receive, in addition to the standard wages of the trade, some share in the final profit of the business, or the economy of production.
 2. That the worker should accumulate his share of profit, or part thereof, in the capital of the business employing him, thus gaining the ordinary rights and responsibility of a shareholder.
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For further Information apply to

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